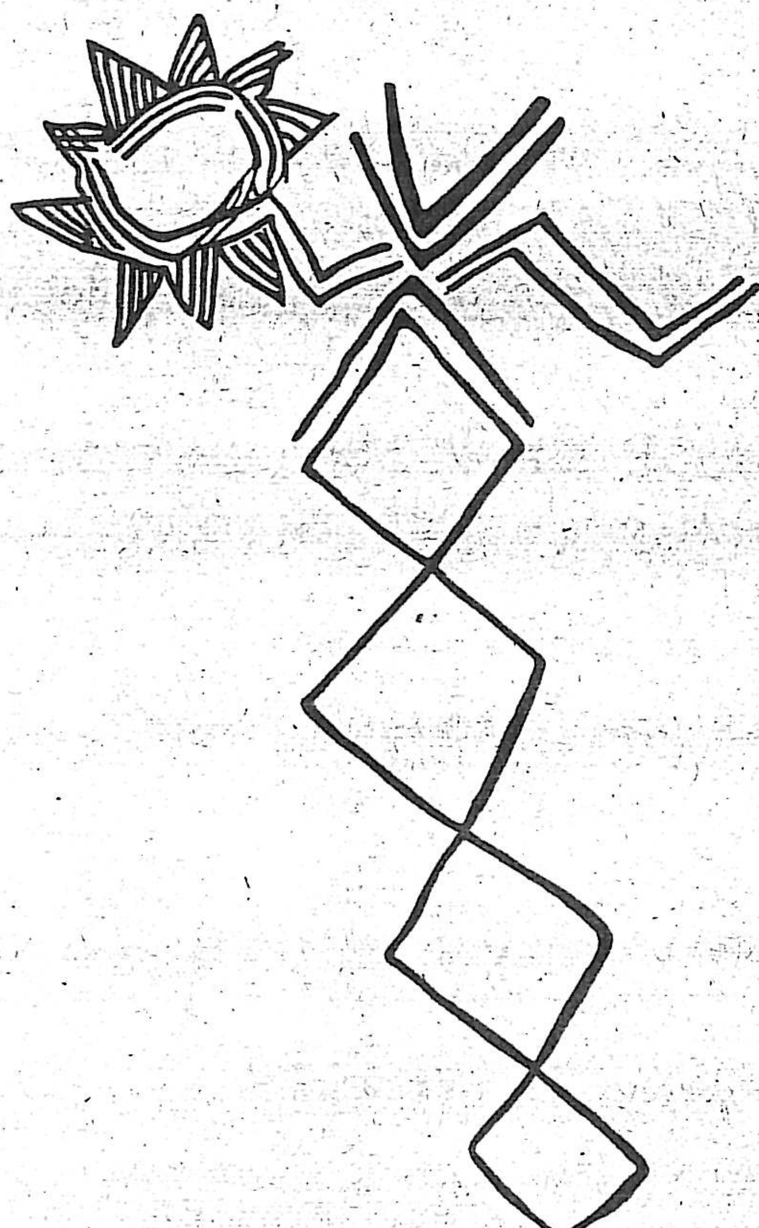
Rock Art of the Chihuahuan Desert Borderlands

Edited by Sheron Smith-Savage and Robert J. Mallouf



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RESEARCH ON THE NATURAL ACCRETION COVERING PICTOGRAPHS IN THE LOWER PECOS

Jon Russ,[1] Richard P. Timm,[2] Cynthia Kenny,[2] Kirkland Hodge,[2] and Warna Kaluarachchi [2]

[1]*Department of Chemistry, Arkansas State University, Jonesboro, Arkansas*
[2]*Department of Chemistry, Sam Houston State University, Huntsville, Texas*

ABSTRACT

The extraordinary pictographs in the Lower Pecos are often covered by a naturally occurring crust containing whewellite. While this crust obscures the art, it could actually protect the paint. The lichen that produced the whewellite apparently flourished in the region during dry climatic periods and could serve as a source of paleoclimate data.

INTRODUCTION

It has been almost three years since I presented "Research on the Natural Accretion Covering Rock Art Paintings in the Lower Pecos," coauthored with my students, Richard P. Timm, Cynthia Kenny, Kirkland Hodge, and Warna Kaluarachchi, at the first Trans-Pecos Rock Art Symposium. Since then my colleagues, students, and I have continued to study the rock crust associated with the Lower Pecos rock art. The results of our research have given us a better understanding of the rock surfaces on which the ancient paintings occur, and we have also found a potential means for reconstructing the climate history of the region based on properties of the rock crust. These recent findings are significant enough to warrant adding them to this paper.

In most cases rock surfaces that contain prehistoric paints are not static but are instead active biogeochemical systems. The result of this activity is the formation of crusts on the rock surface. These natural accretions often cover the prehistoric paints, sometimes protecting them, but also causing them to appear faded. Because the processes that form the accretion may affect the paint materials, accurate and reliable analyses of the paints require that we understand the relationship between the paint components and the natural rock substrate-accretion system. This information is also particularly important for developing informed conservation strategies.

One of the primary components in the rock crust associated with prehistoric rock paints in the Lower Pecos is the calcium oxalate mineral whewellite (Russ et al. 1994; Russ et al. 1995). Until recently whewellite was considered rare in geological environments, but it is now known to be common in accretions on rock surfaces, having been discov-

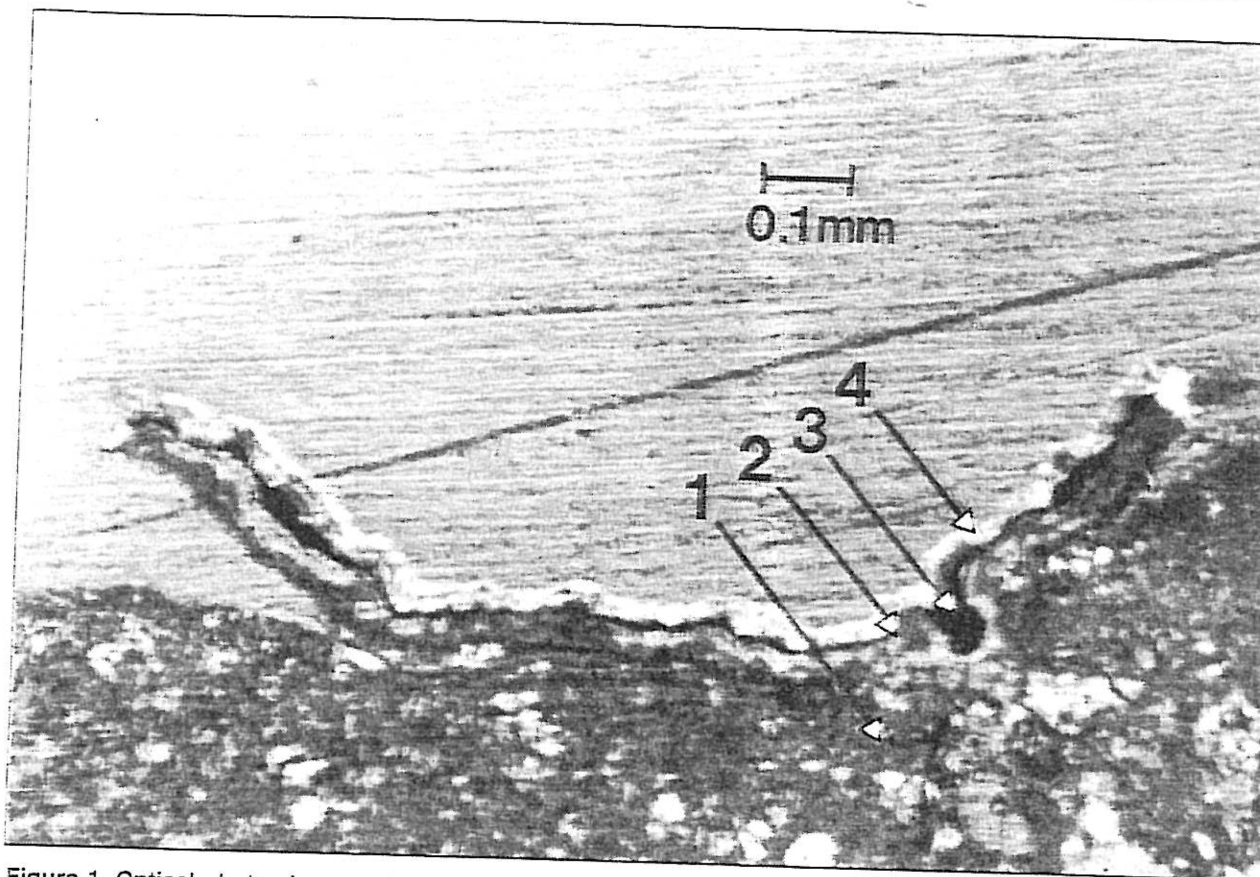

Figure 1. Optical photomicrograph of a thin-sectioned sample that contains prehistoric rock paint. The image shows (*1*) the limestone substrate, (*2*) rock crust below the paint layer, (*3*) the paint layer, and (*4*) rock crust above the paint layer, illustrating that the crust encapsulates the paint.

ered in Italy, Australia, and in the southwestern United States. The source of the whewellite is still being debated; however, research by our group in the Lower Pecos and Alan Watchman's work in Australia (Watchman 1990, 1991) clearly indicate the whewellite has a biological origin. In fact, radiocarbon ages of whewellite in thick (> 1 mm), stratified rock crusts encapsulating prehistoric paints in Australia allowed Watchman to establish the age of a pictograph at nearly 25,000 years old (Watchman 1993).

DESCRIPTION OF THE ROCK ART CRUST ASSOCIATED WITH LOWER PECOS PICTOGRAPHS

The vast majority of limestone surfaces inside rockshelters and under rock overhangs in the Lower Pecos are covered with the whewellite-rich crust. Gypsum, quartz, and clays are the other principal components in the accretion. At sites with rock art, the crust encapsulates the paints causing the pictographs to appear faded or, in at least one site, to be completely obscured from view (Figure 1). The crust is typically less than 0.5 mm but sometimes up to 1.00 mm thick and imparts a yellow to brown color (10 YR 7/4 to 5 YR 4/4, Munsell designation) to the limestone. The surface of the crust is irregular with botryoidal and spherical protuberances extending about 0.5 mm above the surface. The morphology of these surface features resembles that of a lichen found inside two rockshelters in the region and identified as *Aspicilia calcarea*.

Crust samples studied in cross section using an optical microscope and a scanning electron microscope (SEM) usually showed a single layer of crust, though several had distinct stratification. Pictograph samples also contained a thin 30–100 um (0.03–0.1 mm), continuous paint layer incorporated within the crust. In a previous study Zolensky (1982) identified the paint pigments as iron oxides for red paints and manganese oxides for black paints. We also observed iron and manganese in the paint samples we studied, as well as a high incidence of clay materials in the paint layer. This indicates that the source of the pigments either had a high clay concentration or this component was added to the paint mixture. Clottes (1993) used characteristics of clay materials that were added to prehistoric paint mixtures to associate different pictograph motifs at several sites in France, a method that could be fruitful in studying Lower Pecos rock art. It is commonly believed that an organic material was also added to ancient paint mixture to act as a vehicle and/or binder for the mineral pigments, but no direct evidence for such an additive has been obtained. Recently, however, my colleagues and I analyzed a paint sample using a FT-Raman spectrophotometer and established the first analytical evidence for organic matter in Lower Pecos paints (Russ et al. 1995).

Using a SEM with an energy dispersive X-ray analyzer (SEM/EDS), we established the distribution of quartz, gypsum, and clays in the crust and the relationship between these materials and the paints by mapping elements characteristic of the minerals in polished thin sections. Quartz was found primarily in the substrate, as were most of the clays, indicating that the limestone on which the paintings occur is highly siliceous. Gypsum was found to occur throughout the crust and in voids and fissures in the substrate. This occurrence gives further evidence that the gypsum is the result of efflorescence/subflorescence processes (Turpin 1982; Labadie 1990). Furthermore, the gypsum is intimately associated with the paints, generally occurring above, within, and below the paint layers. We also established that the whewellite occurs only in the crust and not in the substrate, and generally in contact with the ancient paints. High magnification SEM images of the crust revealed that the whewellite is microcrystalline, with tabular gypsum crystals occurring as layers and intrusions into the whewellite phase. The crust also contained traces of clay, as indicated by aluminum and silicon peaks in EDS spectra, but no clay particles were observed using SEM. Evidence of microorganisms in crust samples were rarely observed, although Kaluarachchi (1995:67) noted what appeared to be cocci bacteria in one of five Lower Pecos paint samples she studied using SEM. This paint sample came from Site 41VV75.

Our studies of the pictograph paints have focused on very small samples collected at three sites; therefore, our results may not be pertinent for all rock art sites in the Lower Pecos. However, we have studied samples of rock crust from more than 40 sites, and there is a remarkable consistency of the characteristics of the crust at each of these sites.

ORIGIN OF THE WHEWELLITE-RICH CRUST

Prior to the Holocene the primary weathering that occurred inside Lower Pecos rockshelters is thought to be limestone spalling induced by freeze-thaw cycles (Kochel 1982:268). Amelioration of the climate during the late Pleistocene–early Holocene allowed the limestone walls inside the shelters to stabilize (D. G. Robinson, personal communication 1995), and they have remained stable despite xeric-mesic climate fluctuations in the mid to late Holocene. The presence of intact Pecos River style rock art in over 200 rock art sites indicates that many shelter walls have remained stable since at least 2950 to 4200 years B.P., the ^{14}C ages established for the rock art style (Russ et al. 1990; Russ et al. 1992; Ilger et al. 1995). Thus the rock art surfaces have had thousands of years for the crust to form.

In previous reports we argued that our evidence indicated a biological source, likely a lichen, for the whewellite in the Lower Pecos rock crust (Russ 1994; Russ et al. 1994; Russ et al. 1995). Although most of the samples we studied showed microcrystalline whewellite with nondescript morphologies, we recently observed whewellite micro-structures in samples from Sites 41VV576 and 41VV129 that resemble the thallus of *A. calcarea* (Figures 2 and 3). Furthermore, whewellite features on the crust surface resemble the surface of this lichen. *A. calcarea* is a likely source of the whewellite since it is an epilithic lichen (grows on rocks) known to occur on limestone, produces calcium oxalate, inhabits cool or warm xeric environments, and does not contain rhizines (Poelt 1973:619; Wadsten and Moberg 1985). (Rhizines are hyphae that penetrate the rock on which the lichen grows.) Since the paint layers below the crusts are continuous and not disrupted, it is expected that the lichen that produced the whewellite did not have rhizines. Furthermore, we have found this lichen inside two rockshelters in the Lower Pecos, evidence that this organism can survive in these special microenvironments (Russ et al. 1996).

PALEOENVIRONMENTAL IMPLICATIONS

Whewellite was found to be ubiquitous on sur-

Figure 2. SEM photomicrograph showing a cross-sectional view of the thallus of the lichen *Aspicilia calcarea*. The crystals seen in the lichen are calcium oxalate.

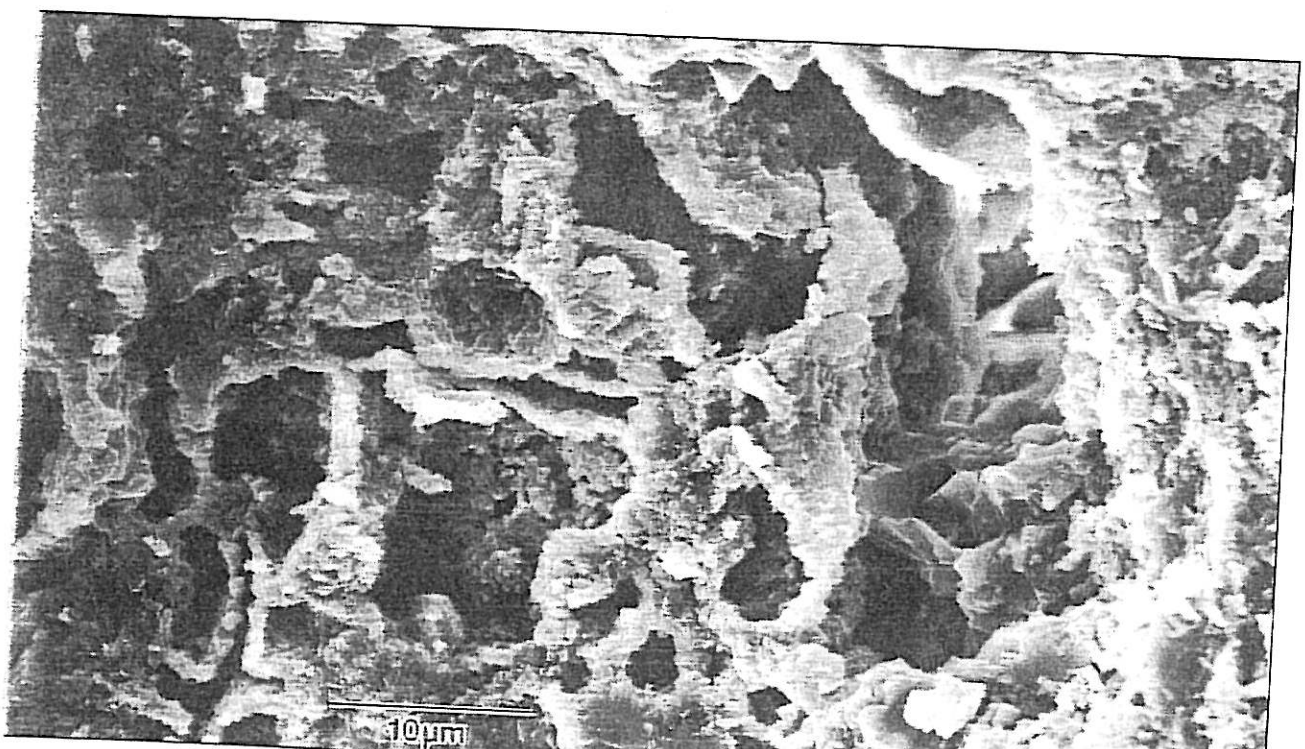

Figure 3. SEM photomicrograph showing a cross-sectional view of a whewellite crust sample. Similarities between micro-structures in the crust and the thallus of *A. calcarea* give evidence that the lichen was the likely source of the oxalate mineral.

faces in sheltered areas throughout the Lower Pecos (Russ et al. 1995), covering vast areas of limestone. This profusion indicates that the lichen that produced the oxalate mineral flourished in this particular habitat. Since *Aspicilia* are xeric lichen, the whewellite was likely produced primarily during dry climate periods, specifically when the substrate was dry. Under these conditions the organism would obtain its requisite moisture by means of water vapor uptake (from dew or fog), a mechanism used by a variety of desert lichen (Kappen 1973; Lange 1988). The oxalate coating produced by the lichen benefits the organism by retaining water and reducing the calcium concentration of the water on the rock surface (Wadsten and Moberg 1985; Whitney and Arnott 1987).

During wet periods the vitality of the lichen would be severely reduced due to a variety of physiological reasons, including response to freezing water (Kappen 1973:328), an imbalance in water conditions that severely limits the vitality of either the fungi or algal components of the lichen (Kappen 1973:325), and inundation with water from the substrate saturated with calcium and sulphate ions. Thus during mesic conditions the organism would be stressed, reducing growth and oxalate production, while gypsum would be deposited on the crust surface and in voids left by decaying lichen matter (i.e., efflorescence/subflorescence).

In Figure 4 we show 14 radiocarbon ages of the whewellite plotted in temporal profile. This plot shows four primary clusters of dates. We suggest that ^{14}C age clusters correspond to periods of dry climate, while gaps in the data indicate wet periods. Most of the clusters correlate with dry climate episodes predicted by Johnson and Goode (1994) based on geomorphological, paleontological, and palynological data mostly from the eastern Edwards Plateau in Central Texas. The gaps in the data, which we suggest indicate wet climate episodes, also correlate with Bryant and Holloway's (1985) paleoclimate model for southwest Texas. Their evidence, based on palynological data from archeological sites in the Lower Pecos, indicates a brief mesic interlude at about 2500 years B.P. This brief wet climate episode corresponds to a gap in our data from 2080 to 2730 years B.P. Two other gaps in our data, from 1330 to 1840 years B.P. and from 3220 to 3990 years B.P., correspond to periods when the human population in the Lower Pecos were at maxima (Turpin 1990).

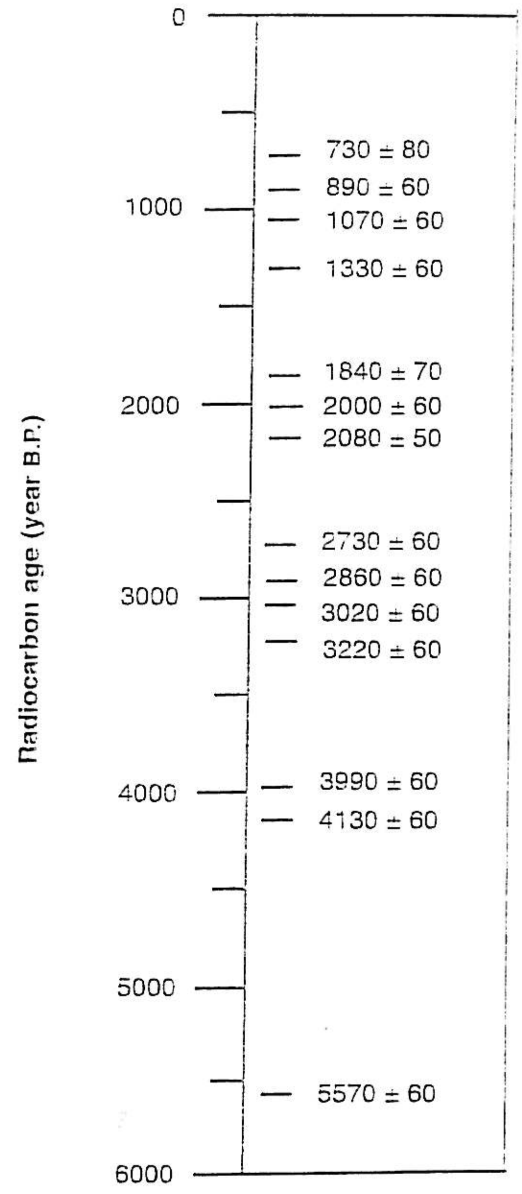

Figure 4. Temporal profile of 14 radiocarbon ages from whewellite samples collected from Lower Pecos rockshelters. We hypothesize that each cluster reflects periods of dry climate, while gaps in the data indicate wet climatic conditions.

CONCLUSIONS

The paints of the extraordinary rock art in the Lower Pecos are encapsulated within a natural rock crust composed primarily of whewellite and gypsum on a siliceous-rich limestone substrate. The ancient paints are incorporated within this crust, which probably protects the paintings from weathering at the surface but causes them to appear faded or obscures them altogether. The majority of deterioration of the paintings seems to be exfoliation of the limestone substrate, not necessarily the crust itself, but it is still unknown as to the cause of the exfoliation. Future conservation research should be directed toward understanding these spallation mechanisms. However, unless particular pictographs are in peril of being lost to natural agents, efforts to remove or treat the crust-containing paints should be avoided. Such treatment could eliminate valuable information regarding the cultures producing the art and the environment in which they lived.

Evidence indicates that whewellite was produced on the limestone inside rockshelters by the desert lichen species *Aspicilia calarea* during xeric climate episodes. We hypothesize that the vitality of the organism waxed and waned in response to dry to wet climate shifts experienced in the region. The lichen produced the stable calcium oxalate (whewellite) residue on the shelter walls during dry periods that can be radiocarbon dated to establish when the lichen flourished; thus the oxalate serves as an indicator of past xeric climate regimes. Based on 14 radiocarbon ages of the whewellite, we infer wet-dry climate fluctuations during the last 5700 years B.P. that are in good agreement with models established for southwest Texas. Since our reconstruction is based on a completely independent mechanism—the vitality of a lichen—it should provide a useful cross-check on paleoclimate models based on other evidence. Furthermore, the ubiquity of the whewellite rock crust in natural environments suggests this technique may be a potentially valuable paleoclimate indicator of wide applicability.

The preliminary paleoclimate reconstruction we propose is interesting in that it indicates an approximate 1,000 year wet/dry climate cycle for the Lower Pecos. Furthermore, each major cultural shift, defined in Hester's (1988) reconstruction of cultural chronology, occurred during a period of whewellite production. Or, put another way, during each period that the lichen flourished in Lower Pecos rockshelters, there was a corresponding cultural change. That there is a cause-and-effect relationship between cultural change and climatic change is certainly not a new concept; however, our evidence may indicate that minor climatic fluctuations could precipitate major cultural responses. We emphasize though that there remains considerable research to test our hypothesis.

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